APPENDIX G
REFERENCE VALUE DEVELOPMENT & TARGET JUSTIFICATION

Reference condition values for various water quality parameters were identified using the guidance presented in **Section 3.0**. In general, reference conditions represent either, conditions that have not been noticeably affected by anthropogenic activities (in other words, natural conditions), or conditions that represent the best water quality/land conditions achievable through the proper implementation of all best management practices if a return to natural condition is unachievable or unreasonable.

Given the potential widespread historical human impacts throughout the Prospect Creek Watershed, the use of internal reference values from within the watershed for reference development cannot be justified for many parameters, and historical data is not available for many parameters. This leaves the use of regional reference data as a remaining primary approach used in many of the following sections. Focus is on the use of regional reference data supplemented by some internal Prospect Creek Watershed data and secondary reference development approaches.

Reference values were identified for the following parameters to help determine impairment for cold water-fish and/or aquatic life:

- Percent Surface Fines in Riffles < 6.35 mm (pebble count)
- Percent Surface Fines < 6.35 mm in Pool Tails and Riffles (grid toss or equivalent)
- Percent Substrate Fines in Pool Tails < 6.35 mm (McNeil cores)
- Pool Frequency (number of pools per unit length)
- Width-to-Depth Ratio (ratio of bankfull width to bankfull depth at riffle cross sections)
- Sinuosity
- Riffle Stability Index
- Large Woody Debris (amount of large woody debris per unit length)
- Riparian Vegetation
- Macroinvertebrate Populations

The above parameters cover a broad range of direct habitat measures and measures of channel conditions, as well as a direct measure of aquatic life (macroinvertebrate metrics). All of the above parameters are measures of sediment-related impairments. Parameters associated with temperature-related impairments include width-to-depth ratio, riparian vegetation, macroinvertebrates and fish.

Percent Surface Fines < 6.35 mm in Riffles (pebble counts)

Reference development considered ongoing reference development work in the Yaak Watershed, macroinvertebrate research, and existing watershed conditions.

Reference development work in the Yaak (EPA and KNF unpublished data) has resulted in < 6.35 mm pebble count percent fines reference data mean values ranging from 10 to 13% for B3, B4, C3 and C4 stream types.

Research by macroinvertebrate specialists (Relya, et al., 2004) indicates that when percent surface fines < 2 mm are between 20 to 40%, based on pebble count data, there is a decrease in macroinvertebrate richness.

For all Prospect Creek sites, mean percent surface fines in riffles based on pebble counts is 16%. The standard deviation for these data is 10%, the 75th percentile is 22%, and the median is 18%. These are not true reference values since Prospect Creek is not in reference conditions, but they do represent values that can be attained and may be tracked to indicate potential increased fine sediment inputs.

Collectively, these data suggest that the percent fines < 6.35 mm target should remain below 15%.

Percent Surface Fines < 6.35 mm in Pool Tails and Riffles (grid toss)

Reference development for percent surface fines using the grid-toss method is based on results from several studies (**Table G-1**).

Percent surface fines impairment threshold for the Blackfoot Headwaters TMDL was set at about 6 percent to 8 percent, representing the 75th percentile of the least impacted reaches suitable for developing reference values. The data was collected from numerous pool tails along two 2200' least impacted reaches. This data was collected using a variation of the grid toss approach referred to as a "viewing bucket" approach.

Average grid toss reference condition values measured in undeveloped watersheds on the Lolo National Forests (USFS, 1998) ranged from about 6% to 8% surface fines, with the upper end of one standard deviation values in the approximate range of 15 to 20%. If non-parametric statistical analysis had been performed on this data set, the 75th percentile would be lower than this 15 to 20% range, suggesting an upper range of 10 to 15%. This is based on graphical data presentations from the USFS report and the fact that the low end of one standard deviation is cropped at 0, both of which imply a skewed distribution. The Lolo data set was collected using a comparable methodology to the data collection in Prospect Creek Watershed.

For all Prospect Creek sites where grid toss data were collected, mean percent surface fines < 6.35 mm was 13%, with a median of 6%, standard deviation of 19% and 75th percentile of 14%. These are not true reference values since Prospect Creek is not in reference conditions, but they do represent values that can be attained and may be tracked to indicate potential increased fine sediment inputs.

Based on the reference information and existing conditions in the watershed, a value of 10% < 6.35 mm is used as a target value. Values above the 10% condition indicate increasing fine sediment loading and can be an indicator of negative impacts to a beneficial use.

Table G-1. Reference Data for Grid Toss Surface Fines (< 6.35 mm)

Source	Percent Fines
Blackfoot Headwaters TMDL Reference Condition	6 – 8 (75th percentile)
Lolo NF (USFS, 1998)	6 – 8 (Average); 15 – 20 (upper end of one standard deviation); 10 – 15 probable range of 75th percentiles
Prospect Creek Watershed	13 (Average); 6 (median); 32 (upper end of one standard deviation of 19); 14 (75th percentile)

Percent Substrate Fines < 6.35 mm in Pool Tails (McNeil core)

Table G-2 presents reference data for substrate fines. DEQ and the Flathead National Forest established McNeil core percent fine reference conditions for the Big Creek TMDL of less than or equal to 30 % substrate fines (< 6.35 mm) for a McNeil core sample. This was based on historical data from Big Creek. Other reference conditions are based on local or regional reference conditions typically in the range of 28 to 35% fines < 6.35 mm. These reference conditions are generally based on a 75th percentile or upper end of a reference range.

Results from McNeil Core sampling by the Kootenai National Forest show average percent substrate fines at reference sites monitored from 1997 – 2003 ranged from 17 to 29% with similar median values **(Table G-2)**. The 75th percentile values typically fall below 28%, and the 25th percentile values are all greater than 15%.

Research in the Blackfoot watershed between 2003-2005 show average percent substrate fines at all monitored sites had a median value of 30%. The 75th percentile values averaged 38% and the 25th percentile averaged 26%. Because the majority of sites were not considered reference, the 25th percentile is the most appropriate value to consider for desired condition.

These data is considered a reasonably applicable representation of expected conditions in Prospect Creek. Therefore, a McNeil Core sample target value of less that 28% substrate fines < 6.35 mm is selected using a regional reference primary approach.

Table G-2. Reference Data for Substrate Fines (< 6.35 mm) Using McNeil Core Sampling

Source	**Percent Fines**				
Big Creek (Flathead)	30 (based on average plus one standard deviation)				
Blackfoot Watershed	26 (based on 25th percentile of entire data set)				
TMDL Targets from Other Watersheds in Western Montana	28 – 35 (generally based on 75th percentile or upper end of reference range)				
Kootenai Sampling (1997-2003)	**Average**	**Stnd Dev.**	**25th Percentile**	**75th Percentile**	**Median**
• Bear Creek	19.0	6.0	16.7	22.5	19.5
• Flattail Creek	26.7	7.2	23.2	28.3	26.0
• Himes Creek #1	29.1	4.4	26.4	28.2	27.5
• Libby	25.4	4.5	24.4	27.9	26.0
• West Fork Quartz (Upper)	17.1	3.6	15.2	18.0	16.5
• Upper Silver Butte	21.0	4.3	19.2	23	21.5

Pool Frequency

Reference values for pool frequency are based primarily on interim INFISH Riparian Management Objectives (RMOs) from the National Forest (USFS, 2000) and reference data from the Lolo National Forest (Riggers et al., 1998). The development of pool reference values is focused on identifying a reference range, with focus on the minimum level that should exist to fully support cold-water fish. Higher the pool frequency typically equates to better habitat conditions. Therefore, values above the high end of the reference range would be desirable in most situations, and values below the low end suggest a potential problem.

Based on interim INFISH Riparian Management Objectives (RMOs) from the National Forest (USFS, 2000) and a review of stream width data for Prospect Creek, pool frequency reference development was broken into two categories for applying pool reference conditions to streams in the Prospect Creek Watershed. These categories include: 1) B and C stream types of Prospect Mainstem and 2) B and C stream types of tributary streams. B channels are characterized by moderate sinuosity (>1.2), moderate width/depth ratios (>12), moderate entrenchment ratios (1.4-2.2) and a slope of .02-.04. C channels have less slope (<.02), typically greater sinuosity than B channels, slight entrenchment (>2.2) and moderate to high width/depth ratios (>12).

For Prospect Mainstem, the target pool frequency value is 26 pools per mile based on RMO of 26 pools per mile for streams with wetted width of 50 feet. For tributaries to Prospect Creek, the target pool frequency value range is 47 pools per mile. The tributary pool frequency target is based on the RMO of 47 pools per mile for streams with wetted width of 25 feet. Additional reference data from Riggers et al., 1998 suggest that for pool frequency, the 75th percentile in undeveloped watersheds is 66 pools per mile. 47 pools per mile should be considered the minimum target with a desire to achieve greater numbers close to or exceeding 66 pools per mile.

Width-to-Depth Ratio

Reference data sets for width-to-depth ratio include the Lolo National Forest information (USFS, 1998), reference summary data from the Kootenai National Forest (unpublished data, 1998), stream classification criteria and results from within the Prospect Creek Watershed. **Table G-3** provides a summary of the reference information considered.

Historical and existing stream width information from aerial reviews (RDG, 2004) show an increase in stream width from 1947 to 2000. This information from the aerial assessment work provides an important indicator of width-to-depth changes over time since a significant increase in width can indicate a significant increase in width-to-depth. This is in realization of the fact that in 1947 the stream may have already been overly wide due to human impacts prior to that date. These are not true reference values since Prospect Creek is not in reference conditions, but they do represent values that can be attained and may be tracked to indicate potential increased fine sediment inputs.

Based on the reference information considered, selected target values for width-to-depth ratio include less than 30 for B and C reaches of mainstem Prospect Creek and less than 20 for B and C reaches of tributary streams.

Table G-3. Width-to-Depth Ratio Reference Sources and Results

Data Source	Stream Types & Other Stratification	Results (feet)
Lolo National Forest Reference Streams (Riggers, et al., 1998) (recommended ranges based on reference data sets)	B3 & B4 C3 & C4	12 – 22 10 – 33
Kootenai National Forest Reference Data	B3 (stream widths 18 ± 9) B4 (stream widths 13 ± 4) C3 (stream widths 26 ± 4) C4 (stream widths 15 ± 3)	20.9 ± 9.0 (n = 34) 19.4 ± 6.9 (n = 22) 16.0 ± 7.4 (n = 4) 14.7 ± 3.2 (n = 3)
Rosgen, 1996	B C	12 - 40 12 - 40
Aerial Assessment Data for Mainstem Prospect Creek	 C -> D C -> D C -> D	Mean width changes from 1947 to 2000: Reach 2 – 141 to 163 Reach 3 – 126 to 148 Reach 4 – 60 to 68

Sinuosity

Reference data sets for sinuosity reference include Rosgen stream classification criteria (Rosgen, 1996) and existing and historical conditions from within the Prospect Creek Watershed.

Based on the Rosgen stream classification B and C stream types should typically have a sinuosity greater than 1.2.

Historical and existing sinuosity information from aerial reviews (RDG, 2004) shows an decrease in stream width from 1947 to 2000. These are not true reference values since Prospect Creek is not in reference conditions, but they do represent values that can be attained and may be tracked to indicate potential increased fine sediment inputs. Even in 1947 the stream had been impacted by channelization, suggesting the possibility of even higher sinuosity values prior to 1947.

Based on the reference information considered, selected target values for sinuosity range from 1.2 to 1.4.

Table G-4. Sinuosity Reference Sources and Results

Data Source	Stream Types	Sinuosity

Table G-4. Sinuosity Reference Sources and Results

Data Source	Stream Types	Sinuosity
Rosgen, 1996	B	> 1.2
	C	> 1.2
Aerial Assessment Data for Mainstem Prospect Creek (RDG, 2004)		Sinuosity changes from 1947 to 2000:
	C -> D	Reach 2 – 1.15 to 1.06
	C -> D	Reach 3 – 1.25 to 1.14
	C -> D	Reach 4 – 1.16 to 1.08

Riffle Stability Index

Kappesser (2002) examined the relationship between particle size distribution in riffles and the size of largest mobile particles found on nearby bars. The "Riffle Stability Index" (RSI) developed by Kappesser provides a means of evaluating sediment loading to mountain streams. The RSI value is the percent-finer than value from the riffle percent-finer than distribution curve that corresponds to the geometric mean particle size of the bar particles.

RSI values below 40 (<40% of channel substrate is smaller than the geometric mean of the largest mobile bar particles) suggest channel scour exceeds sediment loading, indicating degradation.

RSI values between 40 and 70 (40 to 70% of channel substrate is smaller than the geometric mean of the largest mobile bar particles) suggests channel scour and sediment loading are somewhat balanced, indicating dynamic equilibrium..

RSI values above 70 (>70% of channel substrate is smaller than the geometric mean of the largest mobile bar particles) suggest excess sediment loading.

Based on this information, selected target value range for RSI in Prospect Creek is 40 to 70.

Large Woody Debris

Reference information on large woody debris from several sources was considered. Sources included reference data from Swan River TMDL, Plum Creek Timber Company Habitat Conservation Plan (Plum Creek Timber Company, 2000), unpublished data from Plum Creek Timber Company, Lolo National Forest information (USFS, 1998), unpublished data from the Kootenai National Forest, and interim INFISH Riparian Management Objectives (RMOs) from the National Forest (USFS, 2000). **Table G-5** provides a summary of the reference information considered.

Streams were broken into the same size categories for developing and applying LWD reference values. Similar to pool frequency, greater numbers of LWD typically equate to better habitat conditions. Therefore, values above the high end of the reference range would be considered desirable in most situations, and values below the low end of the reference range would typically

be considered undesirable. The Forest Service RMO of greater than 20 pieces per mile is not protective given the much higher range of values from the other reference results.

Table G-5. Large Woody Debris Reference Sources and Data

Source	**Stream Order and/or Type (Bankfull Width)**	**LWD pieces/mile (not including aggregates)**			
Swan River Tributaries: Jim, Goat, Piper, and Elk Creeks	B & C, 19'-35' (generally 3rd and 4th order)	Range: 105-734 25th Percentile: 158 75th Percentile: 507 Median: 259 Average: 336			
Four Swan River Tributary Reaches in Jim, Goat, and Elk Creeks;	B & C, 35'-45', (generally 4th or 5th order)	25th Percentile: 104 75th Percentile: 210 Median: 108 Average: 206			
Plum Creek HCP Target	Various streams east of Cascades	412 ± 301			
Reported in PCTC HCP, 2000	Western Montana Streams	25th to 75th Percentile: 290-820 Median: 450			
Unpublished Plum Creek Data	Various streams east of Cascades	25th to 75th Percentile: 105-450 Median: 290			
Lolo NF Undeveloped Conditions (Riggers, et al., 1998)	2nd Order B & C	Average: 772			
Lolo NF Undeveloped Conditions (Riggers, et al., 1998)	3rd and 4th Order B & C	Average: 156			
Kootenai NF, Libby Ranger District		Range	25th/75th	Median	Average
	B < 20' (10' - 17')	100-660	168/409	293	333
	C < 20 (15' – 19')	68-211	119/191	170	150
	B&C < 20' (10' – 19')	68-660	163/371	252	293
	B > 20 (21' – 26')	12-754	74/451	149	274
	C > 20' (23' – 32')	264-480	321/429	377	374
	B&C > 20' (21' – 32')	12-754	112/443	264	301
Kootenai NF, Rexford Ranger District	<19.7'	181			
	>19.7'	152			
INFSH RMOs	All	> 20			

Target values selected for large woody debris in Prospect Creek are summarized in **Table G-6.**

Table G-6. Summary of LWD Reference Values for Prospect Creek Watershed

Stream Type and Bankfull Width (Stream Order)	**LWD / Mile Indicator Range**	**LWD and/or Aggregates per Mile Indicator Range**
B & C streams 10' - 20' (generally 2nd and 3rd order)	163 - 371	228 - 519
B & C streams 20' - 35' (generally 3rd and 4th order streams)	112 - 443	157 - 620
B and C streams 36' - 50',	104 - 210	146 - 294

(generally 4th or 5th order streams)		

Riparian Vegetation

Riparian canopy targets are based on the aerial photo analysis and field verification of percent canopy cover on the Prospect Creek mainstem. Based on the results presented in **Appendix C**, targets were derived for percent canopy cover from sites dominated by a mature tree riparian community, which is the desired and historic condition. Consideration is given to differences in active channel width between upper and lower watershed reaches. Riparian canopy targets are 75% or better for active channel widths $\leq$75 feet, and 60% for active channel widths > 75 feet.

Macroinvertebrate Populations

Macroinvertebrate metrics are commonly evaluated and used to help with beneficial use support conditions throughout Montana. The DEQ applies standard protocols for evaluating the macroinvertebrate data based on a primary reference development approach that is commonly updated as more information becomes available. No additional reference development is required within this document; any macroinvertebrate results will be subject to standard DEQ protocols for evaluating the data against reference conditions.